of the latter substance the logarithm of δ was plotted with the density in order to bring out more clearly the relation of the various δ values to the density although an inspection of the tabulated values show that δ is constant. It might be added that helium, while the data are less extensive, gives identically the same result as does argon.

In tables 1 and 2 will be found the comparisons of the pressures calculated for the volumes and temperatures as given by Amagat for nitrogen and Crommelin for argon. The nitrogen pressures calculated show about as good an agreement throughout with the observed pressures as could be expected.

THE CLASSIFICATION OF VASCULAR PLANTS

By Edward W. Berry

GEOLOGICAL LABORATORY, JOHNS HOPKINS UNIVERSITY

Communicated by W. Trelease, February 14, 1917

A scientific knowledge of plants or other natural objects consists to a very considerable extent in a knowledge of their mutual (phylogenetic) relations, hence the necessity of a Taxonomy that will consistently express filiation, which is only another way of stating that it should be phylogenetic. Science does not consist merely of names, but it cannot very well progress without a terminology, and not until this terminology becomes an expression of evolution can it become consistent and itself scientific.

Botanists have rather effectually grappled with this problem in the case of the lower plants, but the classification of the so-called vascular plants remains largely as an inheritance from the study of the end products of their evolution, namely a study of the existing vascular plants, with but slight consideration of the recent progress of paleobotanical investigation.

The not so very long obsolete practice of considering the Angiosperms and the Gymnosperms as subclasses of the class Exogens was a no more pernicious mask of their true relations than the extant usage which considers vascular plants as separable into two great phyla—the Pteridophyta or Sporophyta and the Spermophyta. With the subdivisions of these two groups the present situation is equally inexpressive of our present state of knowledge. To the paleobotanist the Angiosperms and the Gymnosperms are obviously not groups of the same order, the latter including several groups of comparable rank with the Angiosperms as a whole, and extending over a period of time expressed by the ratio of 21 for gymnosperms to 6 for angiosperms.

Furthermore can any characters be mentioned which in the light of paleobotanical knowledge and evolutionary theory are more illogical as the basis for the characterization of great groups than siphonogamy, or the number of cotyledons, or the great stress that is laid upon the morphology of flower parts in the classification of the socalled flowering plants.

The attempt to force the vegetation that clothed the earth five or ten, or fifteen millions of years ago into the taxonomic bounds formulated for the flora of a single geological period, namely—the Present, suggests the petrified asters (Sphenophyllum) which Lehmann described from the Carboniferous, or the cacti, galiums and euphorbias which Lindley once described from the English Coal Measures.

During the long ages of the Paleozoic there were at least four dominant major groups of land plants and a fifth should probably be added, since while the true ferns were not as numerous as was once supposed, the other groups show more or less evidence of having had ferns for ancestors. These other groups that were dominant in the Paleozoic are those of the seed ferns, the Lepidodendrons (and their allies), the Calamites (and their allies) and the Cordaites (and their allies). What can be said of a practice which unites in a single order such complex arborescent quasi seed plants as some of the lepidodendrons and existing club mosses separated by a time interval of many millions of years and by an almost equally great structural gap?

During the Mesozoic the dominant plants were the ferns, cycad-like plants, conifers and ginkgoes, all of which underwent adaptive radiations on all of the continents and which should form the basis for a dozen natural orders instead of but four, in fact Nathorst has already proposed that the cycad-like plants shall constitute a separate phylum—the Cycadophyta.

The proposals that follow were formulated in 1910 and have been tested in university and research work during the interval that has elapsed. They were used in an article on Paleobotany for the new International Encyclopedia (1915) and are put forward in a somewhat categorical manner at the present time as a summary of the present status of paleobotanical knowledge and as an invitation for comments from competent critics.

Phylum **Angiospermophyta** (ἀγγεῖον, a receptacle). Berry, 1915 (Anthophyta).

Phylum **Coniferophyta.** Coulter, 1912, Including the Gnetales.
Coniferales.
Araucariales.
Taxales*
Ginkgoales*
Cordaitales.

Phylum **Cycadophyta.** Nathorst, 1902.

Megaphyllous; leaves compound; stems phyllosiphonic; with primary roots; ciliated sperms. Gymnospermic and strobiloid. Including Cycadales, Williamson iales and Cycadeoidales (Benettitales).

Phylum **Pteridospermophyta.** Ward, 1904. (Cycadofilices of Potonié, 1902).

Megaphyllous; phyllosiphonic; spermophytic, ♂ and ♀ sporophylls little differentiated from the vegetative foliage; gymnospermic but never strobiloid; filicinean in form and habit and much of their vascular anatomy. Including Cladoxylaceae, Lyginodendraceae, Medullosaceae, Cycadoxylaceae, Protopityaceae and incertae sedis including Aneimites, Gigantopteris, Glossopteris, etc.

Phylum **Lepidophyta** (λεπίς, ίδος, a scale). Berry, 1915.

Microphyllous; cladosiphonic, with exarch protostele; homosporous, heterosporous and quasi spermophytic. Prevailingly strobiloid.

Lycopodiales { Lycopodiaceae / Selaginellaceae }
Isoetales
Psilotales†
Lepidodendrales { Bothrodendraceae / Lepidodendraceae / Sigillariaceae }

Phylum **Arthrophyta** (ἄρθρον, a joint). Berry, 1915‡

Stems articulated at the nodes, ribbed. Leaves verticillate, dichotomously compound in the Pseudoborniales and the Protocalamariaceae, palmately laciniate in some Sphenophyllales; pro-

* There is a question whether these two groups with possibly the Cordaitales should not be united as an independent phylum intermediate between the Coniferophyta and the Cycadophyta.

† The Lepidophyta correspond to the Lycopsida of Scott except that he refers the Psilotales to his Sphenopsida (Scott, 1909).

‡ Nearly equivalent to the Articulatae of Lignier and the Sphenopsida of Scott.

gressively reduced during the history of the phylum. Sporangiophoric and strobiloid. Homosporous and heterosporous.

Class Sphenophyllae-Sphenophyllales

Class Calamariae
- Pseudoborniales (Nathorst, 1902)
- Calamariales
  - Calamariaceae
  - Protocalamariaceae (Potonie, 1899)
- Equisetales

Phylum **Pteridophyta** (emended to correspond to the Filicales). Berry, 1915.

Megaphyllous; phyllosiphonic; fructifications on but little modified foliage leaves, never strobiloid; prevailingly homosporous. Heterosporic and quasi spermophytic in certain highly specialized Paleozoic lines, and in existing Hydropterales.

Class 1. Coenopteridae (κοινός, common or general, in allusion to their generalized characters). Seward, 1910*

Class 2. (?) Eusporangiatae
- Ophioglossales
- Marattiales
- Psaronius (Pecopteris), etc.

Class 3. (?) Leptosporangiatae, or Eufilices†
- Osmundales
- Gleicheniales (?)
- Matoniales (?)
- Polypodiales, including Hymenophllaceae, Schizaeaceae, Cyatheaceae, Parkeriaceae, Polypodiaceae.

Class 4. Hydropteridae
- Hydropterales
- Sagenopterales‡

* The Inversicatenales of Bertrand (1909) and the Primofilices of Arber (1906).

† Probably has additional fossil representatives.

‡ The subdivisions of this class are tentative.